STAT

Approved For Release 2009/08/26 : CIA-RDP88-00904R000100110

Third United Nations
International Conference
on the Peaceful Uses
of Atomic Energy

A/CONF.28/P/380
USSR
May 1964
Original: RUSSIAN

Confidential until official release during Conference

NUCLEAR SAFETY REGULATIONS FOR POWER REACTORS IN THE USSR

G.A.Gladkov, G.A.Bat, B.A.Buinitsky, Y.G.Nikolajev,
V.A.Sidorenko

INTRODUCTION

Research and power reactors of various types are operating at present in the USSR. The new reactors that are being developed and built in our country like-wise differ widely in types and in specific design features. Evidently, the variety of reactor types will increase in the future. In this connection an urgent need arose for elaboration of general requirements which have to be accomplished in designing reactors and in selecting their operating conditions to provide maximum safety of reactor operati[illegible]. On the other hand, whenever these requirements are deviated from (which is allowed as an exception only) special safety measures have to be taken, certain operating modes prohibited, etc. One of the most important problem that confronts the designers of nuclear reactor is the provision of nuclear safety, i.e. elaboration of a code of obligatory requirements and measures which would guarantee prevention of excessively quick or uncontrolled power excursion in a reactor.

Elaboration of such general requirements was entrusted to the authors of this paper who prepared a draft of "Nuclear Safety Regulations For Power Reactors in the USSR". This paper contains these Regulations and a brief discussion.

II. Nuclear Safety Regulations for Power Reactors in the USSR

1. Provision of nuclear safety implies specific measures aimed at prevention of a quick or uncontrolled power runaway in a reactor.

2. These Regulations are not valid for critical assemblies and pulsed reactors.

3. In considering emergency situations account must be taken of the possible coincidence of two accidents one of which requires a long time (over an hour) to be explained or liquidated (such as cooling of the reactor).

4. Regardless of their nature the accidents including the melting of the reactor must not result in reactor runaway. The shape, composition and quantity of the fissionable material must ensure double supply before criticality is attained.

5. Changing of the reactor orientation in space, including tipping of mobile and transportable reactors (in transit) as well as sinking of a ship must in no way interfere with the operation of the units which shut down chain reaction.

6. The effectiveness of the reactor safety units must be determined on the basis of the following considerations:

a) if only one reactivity compensation element is provided, the safety elements, minus one, together with one half of the automatic regulator must cover the entire range of reactivity variation from the operating point to the point corresponding to the maximum reactivity on the reactivity versus temperature curve.

b) if the number of the reactivity compensation elements with an operating time shorter than the emergency cooling time is more than one, the safety elements, minus one, must cover reactivity variation between the operating point and the temperature which the coolant has at the inlet to the reactor by the moment when further reactivity control can be effectively ensured by other control elements. In this case, the entire reactivity supply for the complete shut-down of the reactor must be provided by the reaction shut-down elements minus any one of them;

380

c) not less than two safety elements must be available.

7. The safety system must provide safety signalling for the power increase period at least during the start-up and transition to power operation. The operating ranges of the safety system with respect to power and period must overlap. The circuits of the power and period safety systems must contain at least two monitoring channels.

8. It is forbidden to start up a reactor without at least two safety elements in the ready-to-operate position, the effectiveness of the safety elements must be not below β ; the effectiveness of the safety system, minus one safety element, not below $\beta/2$. This requirement must be fulfilled no matter how the reactivity control system is displaced during operation after the reactor start-up, which includes the formation of local piles and xenon waves. The subcriticality of the reactor after the safety elements mentioned above and half of the automatic regulator are placed in the ready-tooperate position must be at least 0,5% of K_∞.

9. The safety elements must not depend for their operation on the provision of external power supplies. When two channels are used, signals from either channel must cause the safety system to operate. Not less than two properly operating safety channels must be provided at all times.

10. The safety system must have provisions for checking the condition of the emergency signalling circuits - from the pick-up to the actuator drives - during power operation without shutting down the reaction. The pick-up circuits must contain current or current unbalance indicators.

11. The effectiveness of the automatic regulation rod must comply with one of the two requirements stated below:

a) $\rho_{ar} < \beta$

b) at $\rho_{ar} > \beta$ the speed of the rod must be such that the reactivity β is inserted at a uniform rate for a time period not smaller than 20 sec. At the same time, the following condition must be fulfilled: $\rho_{ar} < \rho_{ss}$ of the safety system elements minus one of them.

Conditions (a) and (b) are not obligatory when there is a non-inertial effect (as compared to the travel time of the rod)

380

which covers the effectiveness of the automatic regulator.

12. For reactor riding up with periods corresponding to the operating speeds of the automatic regulator (second periods) the derivative $\frac{d\rho}{dt}$ (t - temperature) must remain negative within a sufficiently large interval above and below the operating point.

When the temperature coefficient within some temperature range is positive the maximum rate at which reactivity is inserted during start-up or heat- up must be below the rate at which reactivity is decreased by the motion of the automatic regulator. This limits the power during the heat-up. At the same time the safety elements, minus one of them, must cover the entire positive temperature effect of reactivity variation. In case the reactivity control elements are inserted into the core in emergency situations (during the heat-up) they may be included for compensation of the positive temperature effect.

13. No faults in the circuits and drives of the reactivity control system must cause the reactivity to increase at a rate exceeding that specified in Point 10,b. Moreover, provisions must be made to stop insertion of reactivity whatever fault occurs in the circuits of the reactor reactivity control system.

14. The projects and the operating instructions for the operating reactors must always contain sections on nuclear safety measures to be taken while carrying out maintenance and reloading of the reactor.

15. To enable the comparison of the data relating to reactors of various types, the effectiveness of control and safety elements as well as the effectiveness of all physical processes taking place in the reactor must be calculated in terms of reactivity ρ . The reactivity is found from the formula $\nu(1-\rho) = \nu_{cr}$ (1)

The formula (1) must be used to calculate the full reactivity supply of the reactor ρ and all individual effects ρ_i. The reactivity balance must be drawn up according to the formula

$$\prod_i (1-\rho) = 1-\rho \quad (2)$$

16. In each specific case, the scientific advisor and the chief designer of the reactor installation must submit well-grounded reasons for all deviations from the rules set forth in these Regulations; all such deviations must be approved by the State Commission for the Utilization of Atomic Energy.

380

Note: ρ denotes here the portion of the delayed neutrons for the given core.

III. Discussion

In accordance with their contents the Regulations can be divided into three unequal parts. The majority of the Points refer to the reactivity control system of a reactor and particularly to the safety system (Points 5 through 13). Besides, the Regulations specify the requirements to the reactor system proper (Points 4,5) and, finally, judicial and administrative points (1,2,14,15,16). We will discuss each group in turn.

Before starting the discussion of the problems connected with the reactivity control system we would like to emphasize Point 3 which stipulates the number of accidents in the reactor system. It is supposed that there may be two accidents simultaneously, one of them being of a lengthy nature such as damage of the hermetic sealing of the reactor vessel or failure of some essential mechanism and the other, a short-time one, such as the failure of some control system or short-time interruption of power supply of some mechanism. It is assumed that emergency situations where several accidents occur simultaneously, which are more difficult and complicated than those described in Point 3 are practically non-existant and, therefore, should not be considered in designing reactors. This general assumption is also evident in paragraphs dealing with the reactivity control system of the reactor which consider the possibility that one absorbing rod or a group of absorbing rods actuated by a common drive may fail to operate to perform their immediate function.

A high degree of reliability is required of the elements which shut down chain reaction. Therefore, Points 5 and 13 contain a a number of very stiff requirements which are quite self-explanatory. It should be only noted that the second part of Point 13 requires the provision of facilities which would enable the operator controlling the installation to stop the increase of the reactivity whatever faults may appear in various systems. Point 9 which calls for duplication of control stipulates a similar requirement for the safety system.

380

Points 6 and 8 determine the required effectiveness of the safety system. It is assumed here that after the safety system operates the temperature of the coolant in the core will quickly settle at a value close to coolant temperature at the inlet to the core in power operation. Therefore, quick-acting devices, such as safety elements, are needed to compensate the additional reactivity. Further variation of the temperature in the core and the corresponding variation of the reactivity proceed much slower and can be compensated by the reactivity control elements having considerably slower speed of action. Besides, Point 8 stipulates that at any time during reactor operation provisions must be available to quickly decrease the system reactivity be an amount approximately equal to β, should the reactivity suddenly increase at start-up or during operation. Attention is drawn to the fact that the effectiveness of the safety system is liable to be considerably affected by improper arrangement of the absorbers in the core or by the appearance of xenon oscillations. The Regulations stipulate the reactivity margin to be available until criticality is reached after the safety elements are raised so as to minimize the dangerous effect of errors in preliminary evaluation of the system reactivity prior to the reactor start-up. Points 7 and 10 formulate additional requirements to the safety system. The requirements of Point 10 stem from the fact that separate drives used for the safety system are not checked for condition during long periods of time. All control circuits of the safety system either do not have any objective indications which would characterize their performance during operation of the reactor. Therefore, measures are defined which make it possible, at least partially, to remove this uncertainty - to check the control circuits of the safety system with the reactor operating.

Point 11 indicates how the effectiveness of the automatic regulator must be selected so as to avoid quick power growth in the reactor at any displacement of the automatic regulation rods. When the reactor reactivity is increased by an amount β for a period of 20 sec at a uniform rate, the reactor power doubles after 9 sec. This gives sufficient time margin for the operator and for actuation of the safety system.

38(

Point 12 stipulates the necessity for self regulation of the core within the range of its operating temperatures and prescribes the procedure for starting the system and bringing it to normal operation when self-regulation is absent somewhere outside the operating temperature range of the core.

Of great importance for designing the reactors is Point 4 which stipulates that the reactor design must ensure a 200% margin until the reactor goes critical as a result of core meltdown. In some cases this places considerable limitations on the construction of the lower reflector of the core and the spaces below it.

We will not dwell on the judicial and administrative points which define the scope of application of the Regulations, requirements to record-keeping, etc. It should be only noted that the sole purpose of Point 15 is to ensure uniformity in evaluation of reactivity margin of various systems.